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# Introduction

Virtual Reality (VR) is a “computer generated virtual environment” that a user can “move through” and “manipulate” in real time (Mandal 2013). Outside of its popularity within the gaming industry with games such as Beat Saber (Beat Games n.d.) and SuperHot VR (SuperHot n.d.), VR has also found its place within the world of education and therapy (Checa, Bustillo 2020). In Checa and Bustillo’s literature review, they found that in 2015 with the launch of “new high-quality affordable hardware and software media” for VR there was a significant boost to the number of publications in this area. In addition to VRs role in educating and treating neurotypicals **(studies here)**, applications of VR in this context can also be seen in studies on individuals with autism (Strickland et al. 1996), brain damage **()**.

As seen above, independent travel training is no exception to this. Independent travel training is a form of therapy for individuals with learning disabilities with the aim of helping them achieve independence with regards to solo travel. Studies into the use of VR travel training have found that it can lead to more confidence with independent travel (Bernardes et al. 2015). Another study (Simões et al. 2018) found the use of a VR travel training application to have significantly reduced electrodermal activity (a metric of anxiety) with the subsequent bonus of a high success rate for the application at an impressive 93.8%.

Through a review of the relevant publications within this topic area, a reoccurring theme can be extracted from this, and we can conclude that interaction paradigms for individuals with learning disabilities is either under reported or under researched. This is especially prominent in the case of full immersion into the virtual environment wherein a keyboard and mouse are no longer a feasible option.

Virtual Reality (VR) as a tool for treatment and education has only continued to flourish over the last few decades with research into the area being published as late as the 1990s (Strickland et al. 1996) in favour of its use as a “learning tool” for autistic children. Its application within ‘Travel Training’ research is no exception, as seen in the findings of the predecessor (Sharkey et al. 2002) to this report. Travel training in this context involves the use of a VR application as a training tool to supplement the education of those with learning disabilities with the aim of helping them achieve independence with regards to solo travel.

Studies on individuals with learning disabilities have found that VR travel training can lead to more confidence with independent travel (Bernardes et al. 2015). In one study (Simões et al. 2018), they found the use of a VR travel training application to have also significantly reduced electrodermal activity (a metric of anxiety) with the subsequent bonus of a high success rate for the application at an impressive 93.8%.

This project aims to build upon existing research into the use of virtual reality for independent travel training. To achieve this, the project will focus on a particular question with regards to locomotion in the virtual world and what method might cause the least amount of motion sickness in the application’s users.

As highlighted in (Brown et al. 2002) most participants struggled to use a keyboard and mouse to navigate the virtual world with one participant finding “keyboard control very difficult”. A potential solution to this was identified via the joystick in which one participant had “almost instant success using joystick” on the Zebra crossing level. Subsequent iterations of this project then built upon this by having users walk in place while using the joystick to navigate forwards within the virtual space. Feedback from a few users on this approach found that this resulted in motion sickness and nausea. An alternative to this was to have the user stand still and use a back-and-forth swinging gesture of one arm to trigger movement in the virtual world. This resulted in a reduced reporting of motion sickness. Thus, this gives way to the question of when directly compared against each other, which method of locomotion is the more suitable option for this application. Furthermore, it raises the question of whether other factors might contribute to the reduction of motion sickness when applied to previously used locomotion methods.

When considering motion sickness, it is important to note that its occurrence isn’t entirely uncommon when brought about because of an individual’s immersion into a VR application. One study (Munafo et al. 2017) found in an experiment involving games presented through the Oculus Rift that the “overall incidence of motion sickness” was 56% amongst its 36 participants. The article by Chang et al. found that there are a few different causes of motion sickness in a VR application (Chang et al. 2020). These can be broken down into three main categories: “hardware”, “content” and “human factors”.

With regards to hardware, it is believed that motion sickness can be brought about due to delays generated by the latency effect present within the VR headset’s display as seen in the study by DiZio and Lackner in 1997 (as cited in Chang et al., 2020). The delay between what the user does and what is displayed to them does make for a rather disorientating experience. However, through numerous research papers over the years, several different solutions have been identified some involving hardware (Nguyen n.d.) while others use algorithms (Kumar Kundu et al. 2021) to reduce latency rates.

Nevertheless, studies such as the ones above on hardware and locomotion (López Ibáñez, Peinado n.d.) may not apply to this project’s travel training user base. This study (Wilson 2016) like most others, employs a sample of what can be assumed to be a majority group of neurotypicals and thus without express investigation into its application with those who have learning disabilities it cannot be so easily concluded that lower latency or a particular locomotion method would result in a reduction of motion sickness and thus an improved experience of the application.

Thus, by trialling different methods of locomotion through the application’s content with the inclusion of varying latency rates via VR hardware this project aims to determine the most suitable combination of hardware and content for its VR application based on conclusions drawn from the testing results with the participant group (Oak Field School 2022).

# Aims

The primary aim of this report is to explore the viability of Virtual Reality (VR) to assist people with learning disabilities with independent travelling. This will include detailed primary research from subject experts within the field.

A subsequent aim of this report is to further build upon the existing understanding of navigation methods within the virtual world with the intention of implementing a navigation method that results in a reduction in motion sickness and an overall improved experience of the travel training virtual environment.

# Objectives

* Examine and analyse the current Independent Travel Training process by highlighting the positive impact it has had and its current limitations. Summarise these findings within the report with the inclusion of data collected from interviews with Independent Travel Trainers.
* Learn and gain an in-depth understanding of the experiences of those with learning disabilities, especially regarding independent travel through interviews conducted with subject experts within the field.
* Investigate the current effectiveness of VR as a Travel Training tool through comprehensive research into Travel Training studies and the predecessors to this application.
* Research the various alternative methods of navigation within the virtual world using the library and online resources.
* Explore the means of interaction and navigation within a virtual world for people with learning disabilities
* Design and implement a VR Travel Training application that aligns with existing research and includes new ideas to create a useful tool that can be used by people with learning disabilities to build up their independent travel confidence.
* Upon completion of the design and implementation phase of the project, conduct a series of ethical tests of the newly developed VR Application with the help of the target users, people with learning disabilities. The feedback received during testing is to be used to implement additional improvements to the overall application.
* Conduct research ethically, legally and professionally in compliance with the British Computing Society’s (BCS) Code of Conduct.
* Review and compare this project's results against its predecessors' research and draw conclusions based on the findings. Subsequently, address any remaining questions that could be explored in future work.
* Document and report on the findings of this project in a detailed and comprehensive manner so that it may be used to build upon the understanding of the topic’s impact within the wider research community.

# Tasks and Deliverables

## Project Milestones

The primary milestones for the project are listed below:

* Review Point 1 and Ethics Declaration
* Project Planning Document Submission
* Review Point 2 and Non-Invasive Ethics Application
* Implementation Phase
* Testing Phase
* Review point 3, Showcase Entry and Report Review
* Project Submission Deadline
* Showcase

## Scope

The minimum viable product (MVP) of this project is a VR application that contains at least four types of road crossing levels and includes two forms of locomotion – walking in place with the help of hand gestures and joystick-controlled walking. All relevant tasks will be identified and prioritised to achieve the MVP within the project deadline before any effort is put into exploring the out-of-scope features.

Deliverables outside of this scope would include the addition of more forms of locomotion such as the ability to hop within the VR world or float using a hoverboard as an alternative form of locomotion. Furthermore, the development of a custom set of 3D assets would also be outside of the scope due to how time-consuming the process tends to be. However, in the case that the project is ahead of its schedule, an attempt will be made to create more relevant 3D assets (e.g. houses that fit the local scene instead of using American assets).

## Project Outcome

Upon successful completion of the development and testing of the MVP of this project, the VR application will be prepared to be handed on to the client, the NICER group, to be used at Oak Field School.

## Project Tasks

### Planning

* All research into the project’s background shall be completed by the last week of October and the findings will be documented in its relevant section within the report.
* Research into new solutions for locomotion in VR and causes of motion sickness shall be completed by the first week of November and the key ideas identified from it shall be used to formulate the new ideas section of the report.
* Project methodology shall be finalised by early November and an outline of the testing process shall be created as part of the initial draft for the Non-Invasive Ethics application.
* Implementation shall continue from mid-October by building on the foundations of the prototype version of the application that has developed.

### Implementation

The implementation process will be broken down into a few different phases to focus on specific areas of the VR application. This will include the development of the automated traffic system, level design, user and locomotion mechanics, and menu functionality. With prototypes having already been developed for several tasks within these categories, the implementation process will allow for more time put towards the creation of unique 3D models that would have previously been completely out of scope.

### Post-Implementation

Upon completion of a MVP by late January, preparations for the testing phase will begin and participants will be recruited via the appropriate channels of communication. The feedback received from the testing process will be documented and used to supplement the post-implementation changes made to the application so that it is in line with client expectations.

### Documentation

The research and implementation process will be thoroughly documented in the report throughout the project timeline. Revisions and modifications towards the final version of the report will be completed by early March as the intended project deadline has been set four weeks ahead of its actual deadline to allow enough buffer time for tasks that might take longer than anticipated.

# Gantt Chart

A computer screen capture

Description automatically generated with medium confidence

Graphical user interface

Description automatically generated

# Resources

## Information

* Google Scholar – A well-known search engine designed for academia. It also contains author profiles which allows one to look for ways to contact them when needed.
* Library One Search – This is a good resource to access articles of research that are locked behind a paywall.
* Connected papers – Allows a user to find interconnected papers by displaying a mind map network of papers by similar authors or topics.

## Implementation

* 3DS Max – This will be used to design and animate the 3D models that will be placed within the Unreal Engine VR project.
* Unreal Engine 4 (UE4) – The game development engine that will be used to build the VR world. The implementation of locomotion methods and modification to latency levels will be done through this application. UE4 is a well-known tool for virtual reality world-building (previous iterations of this project have used this too).
* Photoshop or Pixlr – Both will be used to edit textures and create materials for the 3D models and world to achieve a level of realism.

## Testing

* NICER – Individuals with learning disabilities and their trainers who will participate in the testing process of the application. Their feedback will be used to further improve upon the application.
* Virtual reality lab in ISTEC – This will be the location used for the testing phase as it is quite spacious and well-equipped with the necessary kit for testing. This includes the Quest 2 and Pico 3 Pro VR headsets for the participants.

# Risk and Mitigation

Each risk is assessed based on its probability and impact using a scale of 1 to 5 wherein a value of 1 implies that this risk has either a high probability of occurrence or that if this risk were to happen it will have little to no impact on the project’s progress. A value of 5 implies either a very high probability of occurrence or if this risk were to happen it will seriously impact the project’s progress.

The risk score is calculated by multiplying the probability by the impact score to determine its overall potential influence on the project’s progress with a higher score indicating a greater severity. In certain cases, with high impact risks, the mitigative cost might be far greater than others and thus the risk will still need to be taken for the project to continue.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No. | Risk Description | Probability  (1 – 5) | Impact  (1 - 5) | Risk Score  (P x I) | Mitigative Action |
| 1. | Insufficient knowledge and background research on virtual reality or travel training methodologies. | 1 | 4 | 4 | All the necessary background research will be conducted before the implementation of the solution through a wide variety of sources as highlighted in the Resource section of this document. |
| 2. | The project suffers from scope creep due to objectives not being well-defined and thus the project becomes too complex. | 2 | 5 | 10 | Clear objectives will be established during the early stages of the project and with the use of Agile methodology, any required changes will be thoroughly and frequently reviewed before approval. |
| 3. | The chosen resources are not suitable for the project. | 2 | 3 | 6 | A thorough review of the required resources will be conducted, and a justification will be provided based on research done before the start of the project. |
| 4. | The project suffers from a time crunch due to poor scheduling. | 2 | 5 | 10 | A Gantt chart will be used to map out key deliverable dates and will include the necessary flexibility in case a certain element requires more time than previously anticipated. |
| 5. | Loss of some or all of the project’s 3D assets. | 2 | 4 | 8 | All assets will be backed-up via a hard drive in addition to being stored on a private GitHub repository. |
| 6. | Loss of some or all the project’s documentation. | 2 | 4 | 8 | All documentation will be backed-up via a hard drive in addition to being stored on a private GitHub repository. |
| 7. | Loss of some or all parts of the Unreal Engine project files. | 2 | 4 | 8 | All Unreal Engine project files will be backed-up via a hard drive in addition to being stored on a private GitHub repository. |
| 8. | Equipment malfunctions during the testing stage | 3 | 4 | 12 | All equipment will be tested a day before the actual testing session in addition to being tested once again before the session begins to ensure everything is still functional. A backup set of equipment will be prepared when possible. |
| 9. | A major bug is found during the testing stage. | 2 | 4 | 8 | The project will have two testing phases in which the initial one will be used to gather feedback from the clients on any bugs or requirements that they would like the project to address. |
| 10. | Due to the shared use of Virtual Reality headsets and gear, participants might be at risk of COVID-19. | 3 | 3 | 9 | All equipment will be sanitised before and after each testing session in addition to being sanitised between use by testing participants. All participants will also be asked if they’ve had any symptoms before joining the testing session. |
| 11. | Participants experience some form of headache or eye strain because of the extended use of the VR application. | 3 | 2 | 6 | Participants’ time spent immersed within the application will also be limited as a means of reducing the probability of the risk’s occurrence. |
| 12. | Participants experience some form of motion sickness, nausea, or vertigo because of the VR application. | 3 | 2 | 6 | A discussion will be had with the participant before, during and after the testing stage to identify and mitigate any risks. Their well-being will be monitored to spot any adverse reactions to the application during the session. Participants’ time spent immersed within the application will also be limited as a means of reducing the probability of the risk’s occurrence. In the case they do experience any of the risk’s symptoms, they will be invited to have a break and given the opportunity to continue later once they have recovered. |

# Legal, Social, Ethical and Professional Issues (LSEPIs)

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